Validation of the TrackLab Positioning System in a Cow Barn Environment

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Introduction

Position data provides the means to track cows' activity and movement in a barn. This information may, for example, help in heat detection [1] or allow social relations in a herd to be studied [2]. We can identify the following requirements for a cow positioning system: The accuracy should be less than 1 m [3] and the sampling rate should be high enough [3], for measuring e.g. cow's speed. The system should be able to track multiple cows simultaneously [2].

However barn environment also has certain challenges::

- There are lots of metal structures in barn environment that may cause reflections of signal and artefacts [2, 3].
- Hardware, especially tag attached to the cow, should be dust- and water-resistant [2].
- Tag should be ergonomic and small [2]. It should not prevent animal's normal movement or behaviour.
- Long battery life [2]. However, often battery life in positioning tags is short (e.g. 24 h in [1]) and higher sampling rate means higher energy consumption and decreased battery life [2, 3].

TrackLab (Noldus Information Technology, Netherlands) is a commercially available system for recognition and analysis of spatial behaviour. It collects location data with Ubisense real time location system (Ubisense, Germany) which is based on Ultra Wide Band (UWB) radio signals. Animals are monitored by means of a tag (Ubisense Series 7000 Industrial tag) that transmits UWB pulses of extremely short duration and remote sensors (Ubisense Series 7000 IP Sensors) which enable location to be mapped by using Time-Difference-of-Arrival (TDoA) and Angle-of-Arrival (AoA) techniques. Maximum sampling rate is 137 Hz. MTT CowLab® is the first barn environment where the TrackLab system has been installed and tested. With six sensors it enables tracking the position of 50 cows simultaneously with accuracy of 30 cm.

The aim of this study was to validate the accuracy of the Tracklab system in a real barn environment. Here we present the result from the first TrackLab validation experiment in our cow barn.

Materials and methods

The positioning system was validated with a single measuring point test (SMPT) for 10 tags, and an accuracy test (AT) for 2 tags. The sampling rate was 1 Hz. In SMPT, tags were held for one minute in 12 predefined measuring points, with coordinates known from the barn. In AT, the tags were moved back and forth on eight specific measuring lines (3.45–3.63 m) determined by a wooden plank mounted on the top of the cubicle structures. The coordinates of the measuring lines' endpoints were known. In SMPT every sample points' distance to the true measuring point was calculated using euclidean distance :

$$P_1P_2 = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

and in AT distance to the true measuring line:

$$d = \frac{a_{x0} + b_{y0} + c}{\sqrt{a^2 + b^2}}$$

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Results and discussion

In SMPT the distance of the sample point and measuring point was 0.17±0.17 m (mean±SD; median 0.16 m; min–max 0.02–2.03 m, see Table 1.). Twenty-seven out of the 465 sample points (6 %) had higher distance than the 30 cm promised accuracy by the manufacturer. In AT the distance to the measuring line was 0.10±0.09 m (mean±SD; median 0.08 m; min–max 0–0.74 m, Table 2.). Sixteen out of 343 sample points (5 %) had higher distance error than that claimed by the manufacturer. Figures 1 and 2 give example of sample points in two measuring lines.

Table 1. Mean, standard deviation, minimum and maximum of the distances (m) between sample points and measuring points

Measuring point	Tag	Mean	SD	Min	Max	The number of sample points
1	051-157	0.19	0.11	0.12	0.47	17
	062-077	0.12	0.01	0.11	0.17	29
2	053-105	0.08	0.01	0.06	0.10	34
	053-119	0.06	0.01	0.04	0.08	24
3	051-157	0.25	0.03	0.17	0.28	35
	062-077	0.26	0.02	0.20	0.29	32
4	053-105	0.16	0.00	0.16	0.17	13
	053-119	0.10	0.01	0.08	0.11	11
5	051-157	0.31	0.39	0.12	1.61	31
	062-077	0.22	0.12	0.12	0.51	9
6	053-105	0.15	0.09	0.07	0.34	9
	053-119	0.20	0.02	0.17	0.25	9
7	053-101	0.10	0.04	0.06	0.14	3
	053-165	0.15	0.23	0.03	0.91	34
8	053-103	0.25	0.01	0.24	0.27	22
	053-159	0.24	0.01	0.22	0.25	15
9	004-190	0.12	0.04	0.07	0.21	18
	053-162	0.19	0.04	0.10	0.25	17
10	004-190	0.51	0.46	0.27	2.04	15
	053-162	0.23	0.03	0.20	0.30	17
11	053-101	0.09	0.02	0.04	0.12	36
12	053-103	0.17	0.01	0.16	0.19	25
	053-159	0.12	0.01	0.11	0.13	10
Total		0.19	0.17	0.03	2.04	465

Table 2. Mean, standard deviation, minimum and maximum of the distances (m) of sample points to the measuring lines

Measuring line	Tag	Mean	SD	Min	Max	The number of sample points
1	017-189	0.07	0.06	0.00	0.16	16
	048-021	0.11	0.09	0.01	0.38	21
2	017-189	0.06	0.04	0.00	0.13	17
	048-021	0.05	0.03	0.01	0.10	16
3	017-189	0.04	0.03	0.00	0.09	22
	048-021	0.02	0.02	0.00	0.07	15
4	017-189	0.07	0.05	0.00	0.20	22
	048-021	0.06	0.05	0.00	0.13	20
5	017-189	0.09	0.04	0.01	0.19	23
	048-021	0.12	0.03	0.07	0.16	23
6	017-189	0.13	0.06	0.07	0.32	26
	048-021	0.09	0.04	0.01	0.19	27
7	017-189	0.09	0.05	0.01	0.16	22
	048-021	0.06	0.04	0.01	0.19	24
8	017-189	0.24	0.18	0.03	0.74	23
	048-021	0.16	0.13	0.01	0.45	26
Total		0.10	0.09	0.00	0.74	343

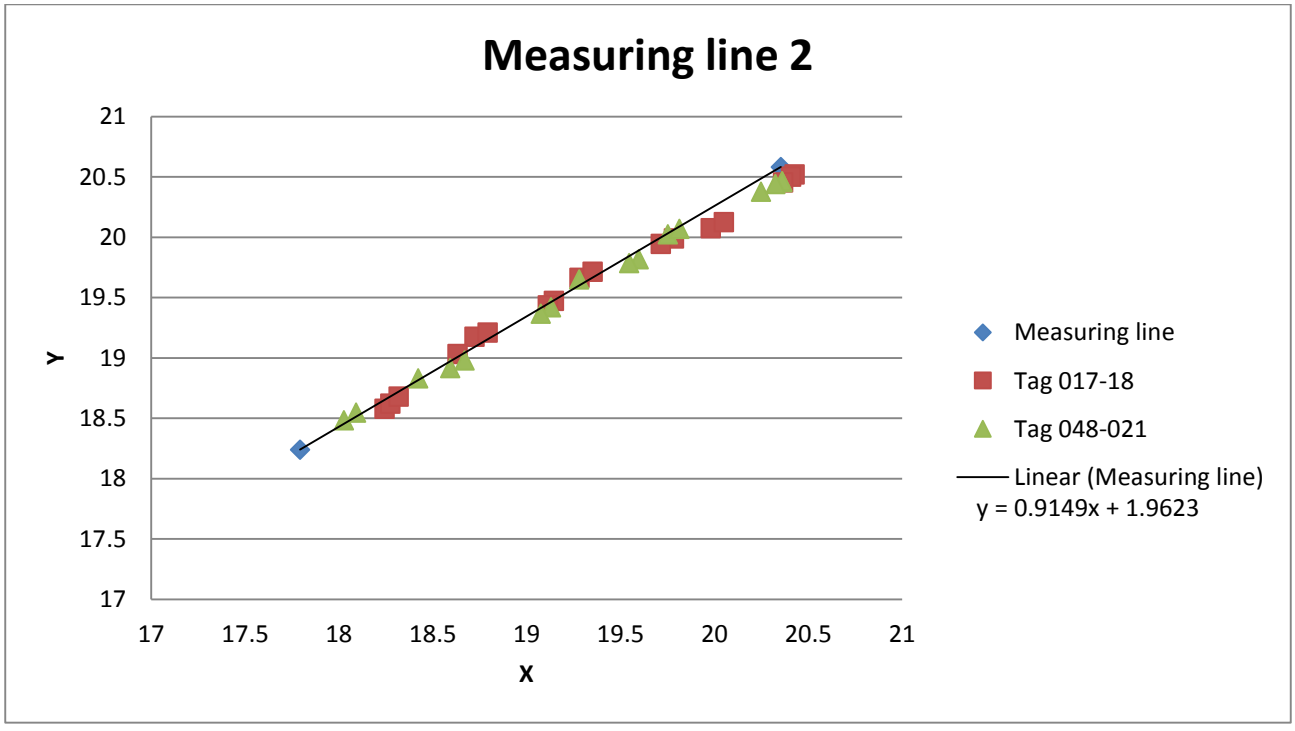

Figure 1. Measured sample points in measuring line 2

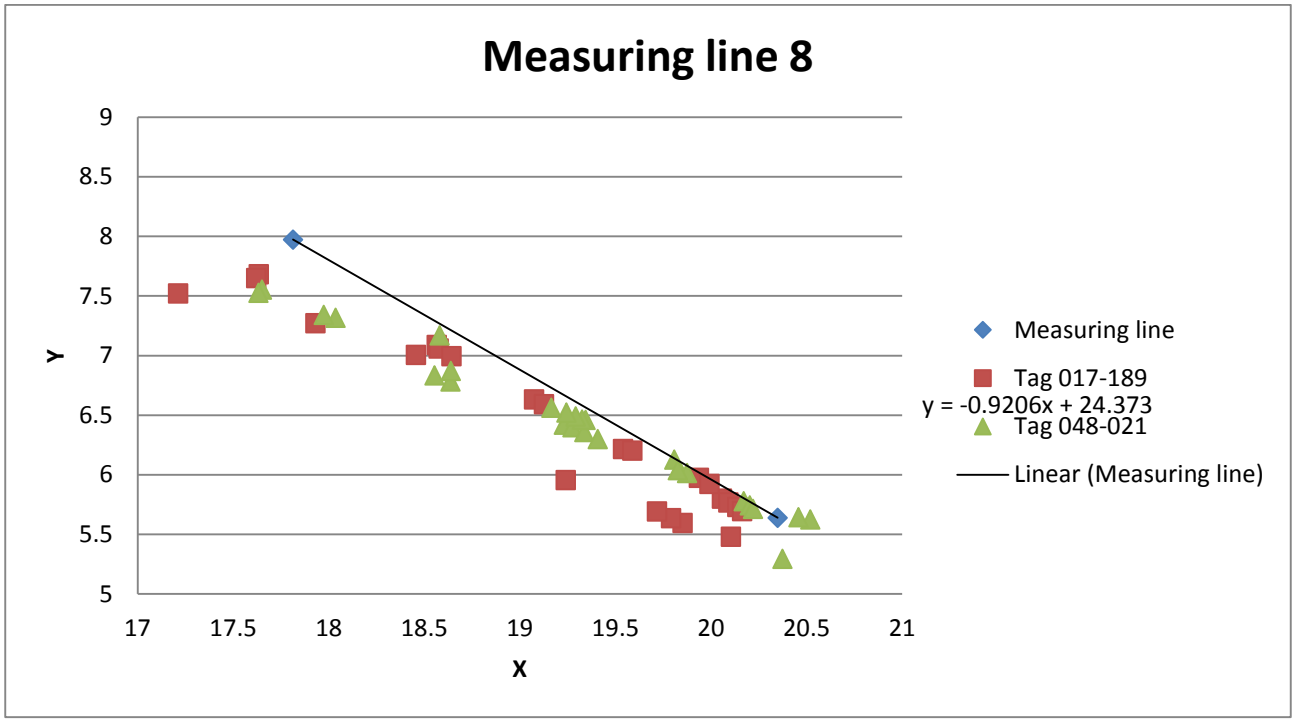

Figure 2. Measured sample points in measuring line 8

Approximately 95% of sample points were within the promised accuracy. Most of the clearly deviating values seemed to occur when the sensors temporarily lost signal of the tag. At least two out of the six sensors need to get the signal of the tag for a valid positioning. Possible reasons for losing the signal were barn structures. The body of the experimenter could have also blocked the signals. Metal surfaces, e.g. in feeding station, probably reflected the signals and, thus, caused artefacts. In conclusion, TrackLab with Ubisense system is a promising tool for positioning in a cow barn environment. However, more validation tests will be carried out, especially in real life situations with cattle and also different data filtering options will be explored.

References

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